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- USSR -

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-USSR-

[Following is a translation of an article by L. A. Sena, Doctor of Physicomathematical Sciences, in Vestnik AN SSSR (Herald of the Academy of Sciences USSR), No. 12, Moscow, 1959, Pages 94-95.]

The study of the processes occurring in collisions of electrons and ions with the atoms and molecules of gases constitutes one of the most important fields of gas electronics. Interest in this field has grown, particularly in recent years, in connection with the extensive development of the physics of hot plasma, astrophysics, and the physics and technology of accelerating charged particles. Understanding the elementary processes which take place in electron and ion collisions is also very important in studying electrical phenomena in all layers of the atmosphere (storm discharges, physics of the ionosphere), and the development of ionic instruments of different types for mass spectroscopy, radiation chemistry, etc.

The First All-Union Conference on Electron and Ion Collisions, held in Riga in the period 26 June--3 July, aroused great interest among the physicists of the nation.

The Conference devoted its main attention to the following problems: the collision of electrons with atoms, chiefly from the viewpoint of determining the functions of excitation and ionization; inelastic collisions of positive ions with atoms and molecules; charge-exchange, particularly resonance; and the formation of negative ions. The discussion of all these problems was interesting and fruitful, and good contact was established between theoretical and experimental scientists. The symposium also proceeded in a very lively manner. Certain problems which had aroused the greatest interest at the conference were discussed here: the ionization of heavy particles near the energy threshold, repeated ionization by electronic impacts, and resonance charge-exchange.

The Conference was opened with a survey paper by L. A. Vaynshteyn devoted to general quantum mechanics methods for calculating functions of the excitation of atoms by electronic impact. The methods developed recently for such calculations take into account the possibility of using electronic computers and permit computing with high accuracy. The results of concrete calculations of excitation functions were also given in a number of the other papers (G. G. Dolgov and L. A. Vaynshteyn, V. Ya. Vel'dre, R. Ya. Damburg, V. Ya. Kravchenko, R. Peterkop).

Electron collisions were also touched upon in the paper by Yu. N. Demkov "Variational Methods in the Theory of Collisions." Papers on the experimental study of the excitation functions of certain atoms and molecules were heard with interest. Here mention should be made of the research done by I. P. Bogdanova, who applied an original method for measuring excitation functions at levels with low threshold energies.

The extensive experimental studies of inelastic collisions of heavy particles (ions, atoms, and molecules) carried out in the Physico-Technical Institute of the Academy of Sciences USSR under the leadership of V. M. Dukel'skiy and N. V. Fedorenko have attracted attention for a long time, both in the Soviet Union and abroad. N. V. Fedorenko gave a survey of the experimental data obtained as a result of investigating ionization in ion-atom collisions in a region of energies in the thousands of electron volts.

G. F. Drukarev reported on theoretical methods for calculating effective cross sections (constituting measures of the probability of the process) of the processes of the collisions of heavy particles. It is necessary to note, however, that the quantum mechanics theory of these processes, which play an important role in the operation of the instruments used in carrying out experiments on controlled thermonuclear reactions, is very little developed. Noticeable success has been obtained in recent years in this field by the Soviet theoretical physicist O. B. Firsov, who has constructed an approximate quantum mechanics theory which gives a general formula of the effective ionization cross section as a function of the velocity of the ions. As shown in N. V. Fedorenko's paper, O. B. Firsov's formula agrees in a qualitatively satisfactory manner with the experimental data for a fairly large number of the processes that were studied. Coworkers in the laboratories of N. V. Fedorenko and V. M. Dukel'skiy (V. V. Afrosimov, I. P. Flaks, Yu. F. Bydin, and others) presented a number of papers on the study of certain types of collisions of heavy particles (ionization of fast alkali atoms in collisions with molecular gases, formation of multi-charge ions, and scattering of multi-charge ions accompanied by the capture of electrons).

The process of charge-exchange between the ion and the neutral atom (charge-exchange) plays an important part in gas electronics. The case of resonance charge-exchange, in which the ion and the atom belong to the same gas, is of particular interest. The papers by A. M. Bukhteyev and Yu. F. Bydin, R. M. Kushnir and I. M. Buchma, and D. V. Chkuaseli were devoted to the investigation of resonance charge-exchange in pairs of alkali metals for which, according to theory, the probability of charge-exchange is particularly great. There is a noticeable divergence in the data obtained in this research, but they support the conclusions of the theory both in the order of values and in the observed patterns.

The paper by Ya. M. Fogel' and his co-workers was concerned with the investigation of the formation of negative ions and their collisions with gas atoms. In analyzing the results obtained, Ya. M. Fogel' showed that the patterns of negative ion formation fitted well in the framework of Messi's adiabatic hypothesis. The problem of the treatment and applicability of this hypothesis was the object of the discussion initiated by the short paper given by G. F. Dukel'skiy establishing the connection between the characteristic dimension contained in Messi's criterion and the most probable value of the transmitted impulse.

Several papers on individual problems were also read at the conference: on the transfer of energy in molecular collisions (Ye. V. Stupochenko and A. I. Osipov), on the theory of oscillatory relaxation and thermal decay of diatomic molecules (N. D. Sokolov and Ye. Ye. Nikitin), on the role of step processes in the formation of protons in ionic sources (M. D. Gabovich), and others.

The content of the papers presented at the conference and their discussion showed that Soviet scientists have achieved significant progress in this important field of theoretical and experimental physics. The theory of a number of processes was developed markedly. Original experimental methods were worked out and applied which were frequently more highly perfected than those in foreign laboratories. It is especially noteworthy that several scientific schools were established in the field of research in electron and atom collisions (Moscow and Leningrad Universities, the Physics Institute imeni Lebedev, the Leningrad and Khar'kov Physico-Technical Institutes, the Institute of Physics of the Academy of Sciences of the Latvian SSR, and others). At the same time, each of them is developing its own objectives and methods, and is training young scientists.

In spite of the progress noted here, however, it is not possible to consider the development of the physics of electron and atom collisions as adequate. Not enough attention has been devoted to many processes of electron collisions (the excitation of energy levels of ions by electron impacts, the radiation given off in the collision of heavy particles, and others). Little work has been done on collisions of particles with very low energies (close to thermal).

The delegates to the Conference directed attention in the resolutions they adopted to the shortcomings enumerated above and recommended concrete ways for eliminating them. Plans were made to convene meetings similar to this conference periodically and to establish a coordinating council on electron and ion collisions in the Department of Physical and Mathematical Sciences of the Academy of Sciences USSR.

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